Table 3. Corn yields reported in Afghanistan, 1956-1966.

Variety	Planting Method	Plant Population	Fertilizer	Yield*	Planting Date	Location	Scope	Reference
	R = row B = broad-cast	1000/ hectare	kg/hectare	metric ton per hectare				
Local	B	--	--	1.40	--	Afghanistan	Estimated ave.	9
"	"	--	--	1.39	--	Shamalon	"	1
"	"	134	manure	3.52	June	Logar	15 fields	10
"	"	147	"	6.84	"	Sha-Waki	1 field	"
"	R	40	--	1.91	May 26	Kabul, Chilsu-toon	1 demonstration	12
"	B	114	--	5.68	"	"	"	"
Minnesota-13	R	31	none	1.55	May 25	Kabul, Ali-Abad	2 years/2 plots	this report
"	"	"	137 N, 53 P_2O_5	2.68	"	"	"	"
Local	B	112	none	2.44	"	"	"	"
"	"	"	137 N, 53 P_2O_5	2.75	"	"	"	"
"	R	106	90 N, 205 P_2O_5	3.18	June 10	"	1 year/20 plots	5
Surcropper	R	24	none	2.45	--	Helmand	37 demonstrations	3
Local	"	23	"	1.21	--	"	"	"
Surcropper	B	21	"	2.40	--	"	"	"
Local	"	32	"	1.53	--	"	"	"
Surcropper	R	26	52 N, 47 P_2O_5	3.03	--	"	"	"
Local	"	25	"	1.60	--	"	"	"
Surcropper	B	24	"	2.79	--	"	"	"
Local	"	36	"	2.07	--	"	"	"
Local	R	72	none	2.34	July 9	Helmand	1 year trial	14
"	"	"	180 N, 0 P_2O_5	3.13	"	" Bolon	"	"
"	"	"	90 N, 0 P_2O_5	3.75	"	"	"	"
"	"	"	0 N, 67 P_2O_5	3.87	"	"	"	"
"	"	"	22 N, 17 P_2O_5	4.19	"	"	"	"
"	"	"	22 N, 67 P_2O_5	4.29	"	"	"	"
"	"	"	0 N, 135 P_2O_5	4.58	"	"	"	"
"	"	"	180 N, 67 P_2O_5	4.91	"	"	"	"

Minnesota-13	R	12	heavy appli-	1.93	May 19	Kabul, Daru-	4 plots	8
"	"	25	" tion	3.22	"	" lamon	"	"
"	"	49	"	3.60	June 5	"	"	"
"	"	87	"	3.98	"	"	"	"
"	"	105	"	4.74	"	"	"	"
Minnesota-13	R	36	none	1.90	May	Kabul, Ali-	1 demonstration	4
"	"	143	"	5.02	"	" Abad	"	"
"	"	36	207 N, 207 P_2O_5	2.30	"	"	"	"
"	"	143	"	5.56	"	"	"	"
"	"	"	16,800 dry alfalfa	6.63	"	"	"	"
Minnesota-13	R	22	none	2.98	May 16	Kabul, Ali-	1 plot	7
"	"	"	207 N, 207 P_2O_5	3.67	"	" Abad	"	"
"	"	49	none	3.52	May 19	Kabul, Daru-	"	8
"	"	"	205 N, 180 P_2O_5	6.24	"	" lamon	"	"
Logar Valley	R	72	--	1.88	July 6	Helmand,	1 year trial	14
Bolon Local	"	"	--	2.02	"	" Bolon	"	"
Dek. 25 (hybrid)	"	"	--	2.03	"	"	"	"
U.S. 13 (hybrid)	"	"	--	2.04	"	"	"	"
Minnesota-13	"	"	--	2.37	"	"	"	"
Surcropper	R	--	--	1.33	--	Kabul, Ali-	5 year trial	13
Minnesota-13	"	--	--	1.46	--	" Abad	3 year trial	"
Yellow Dent	"	--	--	1.99	--	"	"	"
Gehu Squaw	"	--	--	2.01	--	"	"	"
Rainbow Flint	"	--	--	2.11	--	"	"	"
White Dent	"	--	--	1.71	--	"	2 year trial	"
" "	"	54	--	3.13	May 26	Kabul, Chil-	1 demonstration	12
" "	"	"	108 N, 11 P_2O_5	3.91	"	" sutoon	"	"
Hybrid G 26	R	54	none	4.21	May 26	Kabul, Chil-	1 demonstration	12
"	"	"	108 N, 11 P_2O_5	4.96	"	" sutoon	"	"
Hybrid G 24a	"	"	none	5.43	"	"	"	"
"	"	"	108 N, 11 P_2O_5	6.34	"	"	"	"
Hybrid G 75a	"	"	none	5.36	"	"	"	"
"	"	"	108 N, 11 P_2O_5	7.66	"	"	"	"

* Air-dried shelled corn; 1000 kg per hectare = 27.9 seers per jerib or about 16 bushels per acre (assume 1 bu = 56 lb and 1 seer = 7 kg).

Two dashes (--) indicates facts not available.

SUMMARY

A row-planted introduced variety of open-pollinated corn did not exhibit any conclusive superiority over a broadcast-planted local variety, nor was a moderate application of commercial fertilizer economically justified in three out of four cases. These situations were most pronounced in the second year of the study when plant populations were particularly sub-optimal for the introduced corn. This suggests that an improved relative yield as well as an improved response to fertilizer may have been obtained from the introduced corn by having a more optimum plant population.

In other studies reviewed, the row-planted introduced varieties likewise did not exhibit any marked superiority over broadcast-planted native varieties. In most trials reviewed, plant populations of the small local corn varieties were far below the 100,000 to 150,000 plants per hectare (40,000 to 60,000 per acre) apparently required for top yields. In Kabul, the introduced variety, Minnesota-13, has also been most productive from plant stands of 100,000 or more per hectare. Unusually high seeding rates of both local and introduced varieties are apparently required in the Kabul area to compensate for poor emergence of seedlings, insect damage, and problems of soil crust. Under local conditions, commercial fertilizer applied on corn has generally given smaller economic returns than has fertilizer applied on wheat.

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(خلاصه)

یکنوع جواری خارجی بنام (اوپن پالینیتد) (open - pollinated) که بصورت قطار با ماشین کاشته بود نسبت بنوع دیگری جواری وطنی که پراگنده همراه دستکاشته شده بود کدام برتری در حاصلات نشان نداد . همچنان از جمله چار تجربه در سه تجربه ان تطبیق پاروی مصنوعی اقتصادی تمام نشد . در سال دوم چون نوع جوار خارجی از اندازه معمول نسبتاً کمتر در زمین کاشته شده بود مسئله فوق روشن تر گردید . یعنی ازاین نتیجه چنین میشود که اگر از جواری خارجی درفی جریب نسبتاً زیاد ترکشت میشد از یکطرف با پاروی مصنوعی توافق بهتر میکرد و از طرف دیگر از جهت مقدار حاصل نسبت به جواری وطنی نتیجه بهتر بدست می امد .

درمطالعات دیگری که دریں باره بعمل امده جواری خارجی که بصورت قطار کاشته شده نیز کدام برتری نسبت به جواری وطنی که بصورت پراگنده کاشته شده نشان نداده . دراکثر تجاربیکه مطالعه شده است وقتیکه تعداد بته های جواری وطنی کمتر از (۱۰۰۰۰۰) یا (۱۵۰۰۰۰) دریک هکتار (۴۰۰۰۰-۶۰۰۰۰ دریک ایکر) کاشته شده حاصل زیاد داده است . همچنان در کابل نوع جواری مینوسوتا-۳ اخیلی حاصل خیز بوده است . بصورت غیرمعمول در نواحی کابل تخم زیاد جواری وطنی وخارجی از سبب سختی قشر زمین ضرر حشرات و دیگر عوامل باید در زمین انداخته شود . تحت شرائط وطنی استعمال پاروی مصنوعی درجواری نسبت به گندم از نقطه نظر اقتصاد نتیجه کمتر داده است .

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EFFECT OF FERTILIZER AND CULTURAL METHODS UPON LOCAL AND INTRODUCED CORN VARIETIES

H. A. Naitaqi and G. A. Nielsen[1]

This preliminary two-year study compared returns from commercial fertilizer applied on local corn, broadcast planted and subjected to the traditional cultural practices of the Kabul Valley, versus applications on the introduced variety, Minnesota-13, planted, fertilized and irrigated in rows in a typical tractor-mechanized cultural scheme. Earlier reports of corn yields in Afghanistan are summarized and results are tabulated here for the convenience of the reader.

Corn, the second most popular crop in Afghanistan, is reported to yield an average of less than $1\frac{1}{2}$ metric tons per hectare (1, 9). Yet, within the country, yields of 6.8 metric tons of local shelled corn have been reported (10). In one demonstration of introduced hybrid varieties, yields reached 7.66 metric tons per hectare or 122 bushels per acre (12). Yields of more than 12 metric tons per hectare are now reported on individual fields in some parts of the world.

Reasons for low yields of corn in most of Afghanistan are not fully explained. Farmers blame lack of fertilizer (manure) and shortage of water. They are not impressed with a need for new varieties at this time. These opinions were born out by Gul and Pickett in their Agronomic Survey of Six Eastern Provinces (6). Shuman (12) noted barren stalks, prevalence of smut, numerous small ears or nubbins and failure to respond to fertilizers. He also stated that countless generations of corn grown under extremely low fertility conditions as well as overcrowding <u>may</u> have resulted in the loss of that fraction of the germ plasm which carries high yield factors. Adaptable hybrids <u>may</u> be the answer to this problem. He recommended more studies of corn varieties, methods of planting and fertilizer application. A continued shortage of trained personnel has prevented a hybrid seed corn program in Afghanistan.

In the few corn trials conducted in Afghanistan, the emphasis has been on open-pollinated varieties. In summarizing work at the Ali Abad Experiment station in Kabul, from 1956-1960, Sumner (13) reported yields of 19 varieties. Results of 6 varieties were selected for presentation in Table 3 of this report. Average yields of the remaining 13 did not exceed 1.6 metric tons per hectare.

Yields of 21 varieties tested in 1961 at the Bolon station in the Helmand Valley were reported by Vaughn (14). The 5 highest yielding varieties included Afghan varieties from Logar and Bolon (Table 3). Minnesota-13 topped the list with 2.37 metric tons of shelled corn per hectare.

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At the same station, ammonium nitrate and treble super phosphate were band-applied on Logar corn seed in 24 different fertilizer treatments. The highest yield was 4.91 metric tons per hectare, obtained where fertilizer was applied at the rate of 180 kg of N and 67 kg of P_2O_5 per hectare (Table 3).

Yields of corn grown in 15 fields of Logar and Kabul Provinces were reported by Samin (10) to average 3.52 metric tons per hectare. One field yielded 6.8 tons per hectare which is equivalent to 196 seers per jerib or 105 bushels per acre, the highest yield of local corn reported in Afghanistan to date. This field received local fertilizer at the rate of 500 donkey loads per hectare and had 147,000 plants per hectare.

Demonstrations to compare local corn and Texas Surcropper, an open-pollinated variety, were conducted by the Extension Division of the Helmand-Arghandab Valley Authority. Carter (3) reported that Surcropper increased yields 55% over the local short-stalked, small-eared, flint-type variety. Row planting was of little benefit to Surcropper and actually decreased the yield of local corn compared with broadcast planting. Fertilizer application increased yields an average 22½% but was unprofitable on more than half of the demonstrations. By using the three "improved" practices two farmers obtained yields exceeding 6 metric tons per hectare. Results from the project are included in Table 3 of this report.

High plant populations were demonstrated to be important in Kabul for obtaining high yields of Minnesota-13 corn (see Table 3). At Darulamon, yields increased from 1.93 to 4.74 metric tons per hectare as plant population increased from 12,000 to 105,000 plants per hectare (8). Fertilizer was most beneficial where plant populations were high (7,8). The record yield of Minnesota-13 in Afghanistan was obtained where, on a per hectare basis, 16,800 kg of alfalfa hay was plowed under. The very high plant population of 143,000 per hectare produced 6.63 metric tons of shelled corn.

Four methods of irrigating corn were compared by Frahmand and others at the Faculty of Agriculture using local corn, heavy fertilization and equal amounts of water. Corn planted in rows and flood-irrigated in the traditional flat basins, yielded up to 29% more than corn planted on low, medium, or high ridges and irrigated in furrows.

EXPERIMENTAL METHODS

Eight plots measuring 4 by 48 meters were established at the east side of the University Farm, Ali Abad, on the field north of the main drainage ditch in 1965 and south of the ditch in 1966. The soil of the plow-layer had a sandy-clay-loam texture with calcium carbonate equivalent of 20%, pH 8, electrical conductivity of saturation extract

of about 2 mmhos/cm, 25% moisture at field capacity and only ½ to 1 meter of root zone above the water table. The physical condition of the soil was poor, being very hard when dry and sticky when wet and in this respect similar to many Kabul Valley soils that have not been mollified by heavy applications of animal manure or night soil.

In 1965, animal manure was applied at the rate of 26 metric tons per hectare. The experimental area was plowed and disked with tractor-drawn implements. A solution of aldrin was sprayed on the soil before planting to control cutworms. On May 25th, alternate plots were broadcast-planted by a local farmer using his own oxen-drawn equipment and the traditional techniques of planting in the Kabul Valley. Two of these plots were fertilized with ammonium nitrate (33% N) and super phosphate (18% P_2O_5) at the rate of 50.7 kg N and 53.3 kg P_2O_5 per hectare. The fertilizer was broadcast and mixed in with an ordinary stick plow. Seed of the native flint-type corn was broadcast at the usual rate of about 72 kg (2 seers per jerib) or approximately 324,000 seeds per hectare. The seeds were covered by pulling a heavy flat board (mala) across the field.

The other four plots were planted on the same date with an open-pollinated variety, Minnesota-13, in 90 cm rows using a tractor-drawn planter. Seeds were planted at a 6 cm depth at a high rate of 143,000 per hectare. Fertilizer was applied on two plots at the same rates as for the native corn but in bands 10 cm to the side and 5 cm below the seed.

The development of a soil crust, inadequate moisture for germination and seedling development, birds, and other undefined problems reduced the final stand of Minnesota-13 to about 40,000 plants per hectare in 1965. The following year, using a high rate of about 143,000 seeds per hectare, a stand of only 37,000 plants per hectare was obtained on the check plots. The band application of fertilizer at seeding time damaged young seedlings and further reduced the stand to 26,000 plants per hectare. The unfertilized plots of Minnesota-13 were thinned to the same population. The population of local corn after thinning was about 100,000 plants per hectare in 1965 and 125,000 in 1966. Thus for each plant of Minnesota-13 there were about 2½ plants of the local variety in the first year of the project and about 5 the second year.

All of the corn was weeded once and the native corn was thinned by the farmer according to his usual practice. On July 18th, additional fertilizer was applied on all of the fertilized plots, broadcast on the native corn which was already showing tassels on 40% of the plants and side-dressed on the Minnesota-13 which was 70 cm tall and not tasseled. The rate of application was 67.6 kg N per hectare.

The local corn was irrigated for the first time when the plants were about 40 cm tall. The soil was flooded with 6 - 10 cm of water be-

tween border-dikes, a total of six times during the growing season. The Minnesota-13 was irrigated by means of furrows and siphon tubes beginning when the plants were 5 - 10 cm tall. Each of the nine furrow irrigations during the season required at least 6 hours and delivered an estimated 6 cm of water on the area.

The local corn which requires 95 days to mature was harvested and weighed 4 months after planting. The Minnesota-13 was harvested a month later. Subsamples of both harvests were oven-dried, shelled and reweighed to determine moisture content and shelling percentage.

In 1966, the most significant changes in the treatments were as follows: Wheat grown on the site the previous year had been fertilized with urea at the rate of 50 kg N per hectare. Animal manure was not applied. The Minnesota-13 was planted in 70 cm rows with banded fertilizer placed 5 cm to the side and 5 cm below the seed. The second application of nitrogen was increased to 101 kg of N per hectare and was applied on July 5th when a few of the native plants were beginning to tassel and the introduced corn was 35 cm tall.

RESULTS AND DISCUSSION

Fertilizer increased the yield of local corn an average of 32% in 1965 to 2187 kg per hectare and an insignificant 3% to 3317 kg per hectare in 1966. The yield of Minnesota-13 was increased by 111% in 1965 and 36% in 1966 to give respective yields of 3209 and 2151 kg per hectare (Figure 1). Unfertilized, local corn produced an average 57% more grain than Minnesota-13. The Minnesota-13 showed a greater response to addition of fertilizer but still produced slightly less than the local variety. Detailed results are presented in Table 1.

Results of this project would likely have been more favorable to Minnesota-13 if higher plant populations had been obtained. Poor pollination also reduced the yield of Minnesota-13 in 1966. Yields of both varieties might have been greater on soil with a better drained, deeper and more friable root zone. Planting in 50-cm (20-inch) rows would probably improve the distribution of irrigation water and shade more of the soil surface, thereby reducing the soil crust problem and suppressing the growth of sun-loving weeds.

Symptoms of phosphorus and nitrogen deficiency were more pronounced on Minnesota-13 than on the local variety. These symptoms on both varieties were reduced by the addition of fertilizer. By July 15th fertilized corn was much darker green and 1 to 2 feet taller than corn not fertilized.

Husked ears ranged widely in moisture content at time of harvest from 16 to 62%, averaging 45% for the local corn and 31% for the Minnesota-13, which was harvested a month later (Table 1). Fertilizer

appeared to decrease the moisture content in 1965 and increase it in 1966. This apparent inconsistent effect was unexplained. Differences between plots were attributed to soil variability.

Table 2 shows that a total application of 118 to 156 kg of N and 53 kg of P_2O_5 per hectare was generally not profitable. However, since plant population tends to interact positively with fertility level, a somewhat more favorable response to fertilizer would be expected where plant populations were higher and more nearly optimum than in this study.

The Kabul farmer is advised to continue using the local variety and his traditional cultural practice until a better combination of variety and practice is demonstrated. He is advised to try some commercial fertilizer at moderate rates on part of his fields to determine its profitability under the conditions of his own farm.

Table 1. Yields and moisture content of two varieties of fertilized and unfertilized corn, harvested in 1965 and 1966.

Corn variety	Year	Repli- cation	Yield of shelled-corn (15% moisture) Unfertilized	Fertilized	Moisture in corn ears at harvest Unfertilized	Fertilized
			---- kg per hectare	----	---------- %	----------
Local	1965	1	1829	2152	62	50
		2	1506	2223	58	54
Local	1966	1	3550	3335	25	40
		2	2869	3299	31	42
Minnesota-13	1965	1	1614	3191	51	49
		2	1434	3227	37	27
Minnesota-13	1966	1	1363	2116	18	20
		2	1793	2187	16	25

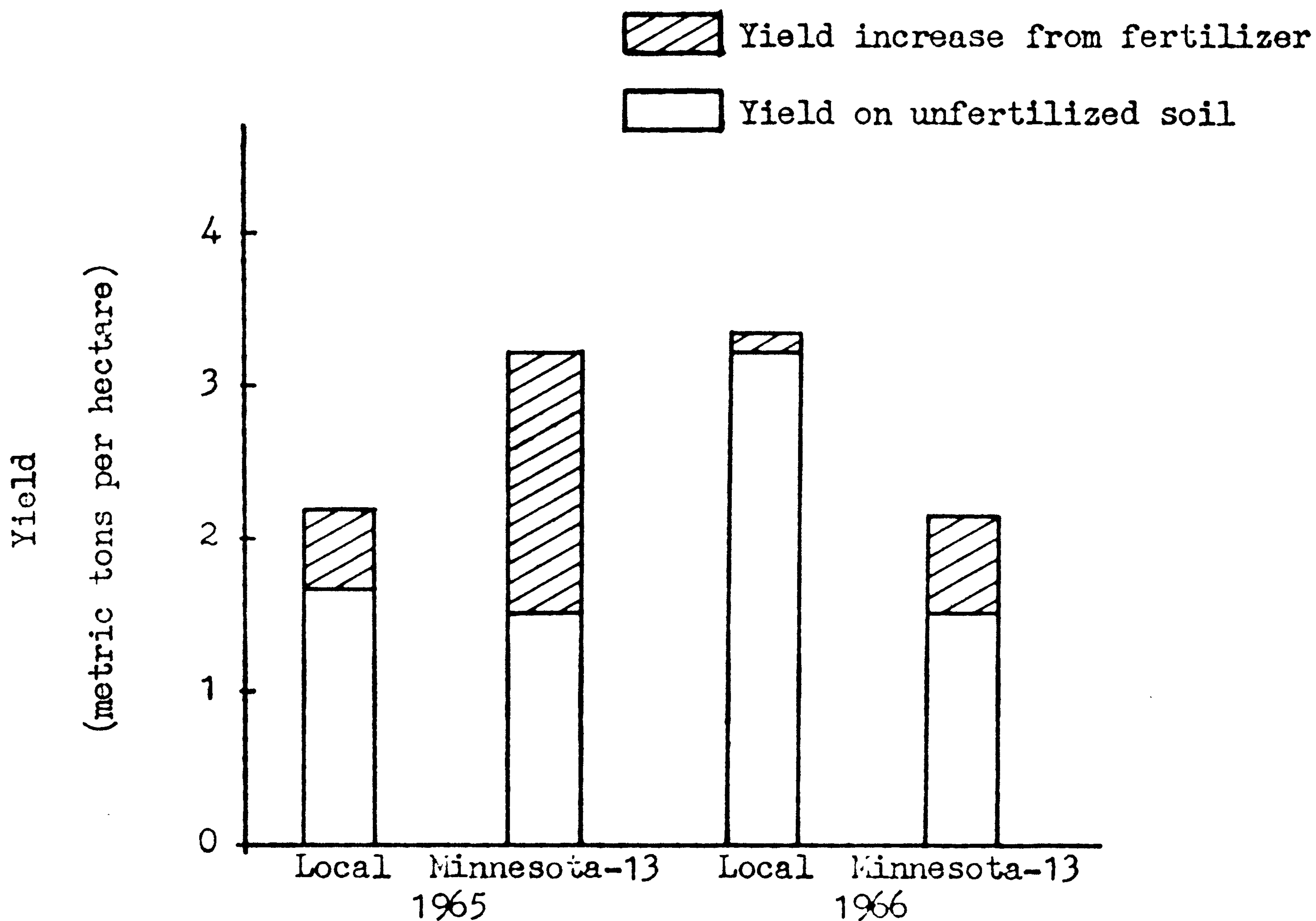


Figure 1. Yield increases from fertilizer applied on local corn and Minnesota-13 in 1965 and 1966.

Table 2. Net returns from application of fertilizer.

	Year	Increase from fertilizer		Cost of fertilizer	Net returns*	Gain or loss per 100 Afs invested
		kg corn/ hectare	---------	Afs/hectare	----	----- Afs -----
Local	1965	520	2210	3293	- 1083	- 33
	1966	107	454	3951	- 3497	- 88
Introduced	1965	1685	4770	3293	+ 1477	+ 45
	1966	573	1622	3951	- 2329	- 59

* Assumed prices in Afs per kg: N, 19.70; P_2O_5, 18.06; Local (flint) corn, 4.25; introduced (dent) corn, 2.83.

Table 3 compares results from available reports of corn yields in Afghanistan dating back to 1956. Conversions were made to the metric system to simplify comparisons and to encourage the use of this system now officially accepted and being introduced throughout Afghanistan.

The following points were drawn from the results shown in Table 3, and from other experience including the present project. These comments are directed particularly to individuals continuing corn research in this country.

1. The potential of selected local varieties should not be underestimated in corn improvement programs. These hard flint varieties are preferred to the starchy dent-types for making corn meal and bread, and therefore bring a higher price in the market. The local corn contains more digestible nutrients, protein, and phosphorus than dent corn. Yields of local varieties have been relatively good compared with most introduced varieties considering that the populations of local plants were generally too low for maximum yields (3, 14). These short-stalked, small-eared varieties under conditions of high fertility, broadcast planting, and a favorable stand of 100,000 to 150,000 plants per hectare, have yielded up to 6840 kg per hectare or 105 bushels per acre (10).

2. A high correlation between plant population and yield of corn has been strikingly demonstrated in Afghanistan. Highest yields of both Minnesota-13 and local corn have been obtained at populations much higher than the 50,000 plants per hectare or 20,000 per acre, generally considered adequate for corn (see data from references, 4, 7, 8, 10,

12, and 14 of Table 3). In Afghanistan the highest recorded yield to date of Minnesota-13 was 6630 kg per hectare obtained from 143,000 plants. Since increasing yields by increasing plant population is inexpensive, the study of this relationship should be given priority along with fertilizer studies and varietal trials.

3. Poor germination and emergence, attack by insects, death of seedlings, and resultant low stands have damaged corn projects of the Faculty of Agriculture more than any other factors. Until these problems are better understood researchers in the Kabul area are advised to plant at least 3 seeds for each plant desired in the final stand, thinning if necessary when the seedlings are well established. Where corn is broadcast planted the soil should be very moist at seeding time and irrigation should be avoided if possible until the plants are nearly knee-high. The clay-loam soils of this area when flood irrigated and exposed to direct sunlight, dry quickly, crack and develop hard crusts which retard the development of seedlings.

4. Broadcast planting and flood irrigation of corn should not be discouraged until a practical alternative has been demonstrated locally. The present trend in the United States is toward higher plant populations, much narrower rows, and better distribution of plants in the available space. With the broadcast planting and thinning technique of the local farmer, a distribution of plants can be obtained which is far superior to planting the small local varieties in 40-inch rows. Although problems of soil crust are reduced by furrow irrigation, preliminary studies of clay loams of the Kabul Valley suggest that the slow capillary movement laterally from the irrigation ditches limits row width to about 30 inches. Narrower rows would be desirable. A preliminary study by Frahmand and others (5) actually indicated that furrow irrigation was inferior to the traditional flood irrigation of corn.

5. Few projects have demonstrated the profitability of applying commercial fertilizer on corn in Afghanistan. On the other hand, fertilizer applied on wheat has in some instances returned over 20 kg of wheat per kg of nutrient or more than 6 Afs per Af invested in fertilizer. Averaging all fertilizer trials on wheat in Afghanistan reviewed by Samin and Nielsen (11), the application of 52 kg of N and 44 kg P_2O_5 per hectare increased yields 46% and returned 8 kg of wheat per kg of plant nutrient and 2.5 Afs for each Af invested in fertilizer. With nitrogen priced at 20 Afs per kg, P_2O_5 at 18 Afs, wheat at 6 Afs and corn at 4 Afs,

present experience in the Kabul area suggests that fertilizers can more profitably be applied on wheat than on corn. Studies of the placement and time of application of various fertilizers, as well as studies on optimum plant populations for various fertility levels, will lead to more efficient nutrient uptake and better returns from both crops.

Results of corn trials in Afghanistan have generally been inconsistent and contradictory. Reliable recommendations for farmers must await more conclusive research.

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